APPLICATION

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FOR

DEFORMABLE PHOTOELASTIC DEVICE

BY

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DEFORMABLE PHOTOELASTIC DEVICE

BACKGROUND OF THE INVENTION

Photoelasticity is a property of certain materials that is used for stress analysis of materials in the fields of scientific measurement and mechanical engineering. Prior methods of using photoelasticity involve measurements of stress distribution within structures.

Needs exist for toys and entertainment devices that amuse as well as to stimulate an interest in science and engineering in children and adults.

SUMMARY OF THE INVENTION

The present invention is a toy, art object, decoration, ornament, entertainment device, advertising device, paperweight or other device made of a deformable plastic material in shapes of prisms, lenses, wedges, cubes, pyramids, as well as other forms that display the changing stress patterns formed by deformations of the photoelastic material. The toy may have one or more magnets embedded within the photoelastic plastic material. Magnets or other devices apply force on the material, deform it, and create fringes generated by the resultant stress pattern. The viewing effects increase the entertainment and aesthetic value of the devices.

A preferred device has a deformable transparent form made of polyurethane or made of a polymer resin placed between two light polarizing films. As light is shown through the object, fringes appear in the object and may be projected on a screen.

Generally, the photoelastic material is a transparent solid. However, the degree of transparency or opacity may vary to enhance the visual characteristics and create different effects in different molded objects. A single object may have regions that are transparent, some regions that are opaque and some regions that are translucent or any combination thereof.

The photoelastic material has characteristics that vary within the same item or from item to item. The chemical makeup of the plastic may vary as long as the plastic is photoelastic. The photoelastic material may also vary in its modulus of elasticity to create variable optical characteristics when stressed. The photoelastic material may be clear or colored. Additionally, color may be varied from one object to another or color can be varied within the same item. Areas of a single photoelastic object can be blue, another red, a third yellow, etc.

The shapes of the toy may be geometric shapes, flexible sheets, prisms, lenses, wedges, cubes, pyramids, amorphous forms, animal or dinosaur shapes as well as other forms that display the changing stress patterns formed by deformations of the photoelastic material. The forms are made in a variety of collectable shapes that create interesting stress patterns.

Magnets may be embedded within photoelastic objects to apply forces for creating fringe patterns. The magnets are molded into the photoelastic object. The magnets either attract or repel the other magnets, forming new and changeable fringe patterns. The magnets may also cause the individual forms to attract and repel each other.

The magnets vary in placement, number of magnets per object, size, magnetic strength, shape and chemical makeup. The magnetic poles of the magnets can be arranged to create different optical effects. The magnets themselves may have a glossy finish to add effects caused by reflection of light.

The plastic shapes and embedded magnets can be formed to exploit other possible optical effects. For example, prism shapes, lens shapes, wedge effects from the interface between the magnet surface and the material presents an additional optical effect to entertain the user.

A polarizing film within, or covering the clear plastic of the entertainment device enhances the viewing effects. One or more polarizing films may be attached to one or more outer surfaces

of the photoelastic material.

Alternatively, if the shapes do not have a polarizing film attached, the photoelastic plastic shapes can be manipulated between two films separated and supported by four posts disposed between the films. Two polarizing films may also be mounted on separate stands to allow more flexibility in viewing the optical effects.

Other options exist for viewing the photoelastic properties of the present invention. A polarized light source may be used. Light from the polarized light source passes through a photoelastic object, through a pair of polarized glasses and into the viewer's eyes. Alternatively, light from an unpolarized light source may pass through a polarizing film, through a photoelastic object and through a pair of polarized glasses before reaching the viewer. Two polaroid films may be used to view the photoelastic object. The polaroid films are rotated with respect to one another to increase or decrease the amount of light passing through the photoelastic object.

Another embodiment of the photoelastic entertainment device involves forming the photoelastic material into a rope. When stretching forces are applied to the rope, the forces create fringes that correlate to the amount of force applied.

Other optical effects may be incorporated into the present invention to enhance the viewing experience of the user. Bubbles or colloidal particles may be dispersed within the molded object. These particles affect the fringe patterns. Similarly, discontinuities, such as cavities, notches and/or curvatures may be introduced to accentuate the fringe patterns through stress concentration. These and other stress concentration techniques may also be employed to increase fringe patterns or to create specific patterns and designs, such as faces, flowers, etc. A thin air interface between embedded magnets or other objects and the photoelastic material produces interference patterns of light. The surfaces of the embedded objects may be shiny or opaque.

This in turn causes visual effects due to reflection or refraction of light.

Other optical effects may be employed in any embodiment of the present invention. This includes porosity of the photoelastic material, colloidal effects and other optical effects including reflection, magnification, diffraction, and interference patterns of light. Additionally, the shape of the photoelastic object may be formed to have the effect of a prism.

Mirrored or other reflective surfaces may be used to enhance optical effects. An opaque object or a mirrored surface may be placed below or embedded within the transparent or translucent photoelastic material. An example of an embedded mirrored surface is an embedded magnet with a glossy surface. The magnet will create fringe patterns when brought near other magnets and through the glossy, mirrored surface. The opaque object or mirrored surface may also be a characteristic of the photoelastic object itself. A photoelastic material may be manipulated between a separate mirrored surface and a polarized film.

The photoelastic entertainment device of the present invention may have an applied photoelastic coating. The applied photoelastic coating is a liquid paint coating or a flexible sheet coating that covers the object. Polarizing films are applied on a surface of the photoelastic material or mounted separately from the photoelastic material. When multiple polarizing films are rotated with respect to one another, the transmission of light is controlled.

Manipulation of stress levels affects stress patterns. External forces, such as manual manipulation and/or one or more of the following: springs, strings, elastic bands, clamps, embedded and/or externally placed magnets and other devices may also be used to create interesting optical effects. Additionally, any combination of devices may be used to create stress patterns. A photoelastic object may be molded with an internal cavity. Another object, with a larger diameter than the internal cavity, is inserted into the cavity. This causes stretching of the

larger photoelastic object and creates fringe patterns. Sharp objects may also be used to create fringe patterns.

Fixed, permanent fringes may be created within the photoelastic objects through curing techniques and permanent deformation strategies.

A separate lens may be used to more easily view the visual effects. A lens may be embedded within the photoelastic object as well. Transparent or translucent protective coatings are applied over outer surfaces of the photoelastic material.

The purpose of the present invention is to amuse as well as to stimulate an interest in science and engineering in children and adults.

These and further and other objects and features of the invention are apparent in the disclosure, which includes the above and ongoing written specification, with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of a molded photoelastic object with a geometric shape.

Figure 2 is a perspective view of a sheet of photoelastic material.

Figure 3 is a perspective view of a photoelastic object molded into the shape of a prism.

Figure 4 is a perspective view of an amorphous shaped photoelastic object.

Figure 5 is a star shaped photoelastic object with embedded magnets.

Figure 6 is a perspective view of a photoelastic object with polarizing films covering each surface.

Figure 7 is a perspective view of a photoelastic object with polarizing films molded into the object.

Figure 8 is a perspective view of a molded photoelastic object between two sheets of

polarizing film separated by posts.

Figure 9 shows a photoelastic object between two movable polarizing films.

Figure 10 shows a photoelastic object between a polarized light source and polarized glasses.

Figure 11 shows a light source projecting light through a toy having polarizing films on opposite sides and projecting the patterns onto a screen.

Figure 12 shows a photoelastic object between two polarizing films that are rotated to produce varying visual effects.

Figure 13 shows a photoelastic object with colloidal particles dispersed within the object.

Figure 14 shows a photoelastic object with a thin air interface within the object.

Figure 15 shows a photoelastic object with a spring between opposite ends for creating optical effects.

Figure 16 shows a photoelastic object with a string or elastic band between opposite ends for creating optical effects.

Figure 17 shows a photoelastic object being compressed on opposite sides for creating optical effects.

Figure 18 shows a photoelastic object with an inner opening for receiving an insert that is larger than the opening for creating optical effects.

Figure 19 shows two photoelastic objects with embedded magnets in proximity to one another for creating optical effects.

Figure 20 shows a photoelastic object compressed by a clamp for producing optical effects.

Figure 21 shows a pointed object contacting a photoelastic object for creating optical

effects visible through a lens.

Figure 22 shows the use of reflection with photoelastic objects.

Figures 23 and 24 show three-dimensional formulations using reflection.

Figure 25 shows a basic general description of embodiments using reflection.

Figure 26 shows an embodiment of a photoelastic device with embedded magnets and reflections

Figure 27 shows the embedded magnet embodiment of Figure 26 with the polarizing film not attached to the photoelastic object.

Figure 28 shows a reflective coating application accessible in three dimensions.

Figure 29 is an embodiment of a candleholder or light fixture.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is a toy made of a soft deformable photoelastic plastic material. The toy may have one or more magnets embedded within the photoelastic plastic material. Magnets or other devices apply force on the material, deform it, and create fringes generated by the resultant stress pattern.

Figure 1 shows a geometric shaped photoelastic object 1. Generally, the photoelastic material is a transparent solid. However, the degree of transparency or opacity may vary to enhance the visual characteristics and create different effects in different molded objects. A single object may have regions that are transparent, some regions that are opaque and some regions that are translucent or any combination thereof.

The photoelastic material has characteristics that vary within the same item or from item to item. The chemical makeup of the plastic may vary as long as the plastic is photoelastic. The

photoelastic material may also vary in its modulus of elasticity to create variable optical characteristics when stressed. The photoelastic material may be clear or colored. Additionally, color may be varied from one object to another or color can be varied within the same item. Areas of a single photoelastic object can be blue, another red, a third yellow, etc.

The photoelastic object 1 is molded into various shapes and sizes. Figure 2 shows a photoelastic object 3 molded into a thin pliable sheet. Figure 3 shows a photoelastic object 5 molded into the shape of a prism. Figure 4 shows a photoelastic object molded into an amorphous shape 7. The shapes of the toys may also be spheres, stars, lenses, wedges, cubes, pyramids, springs, as well as other forms that display the changing stress patterns formed by deformations of the photoelastic material. The forms are made in a variety of collectable shapes that create visually interesting stress patterns. Additionally, objects can be molded into animal shapes or dinosaur shapes to appeal to children.

Figure 5 shows magnets 9 embedded within photoelastic material 11 to apply forces for creating new fringe patterns. The magnets 9 are molded into the photoelastic object 11. The magnets 9 either attract or repel the other magnets 9, forming new and changeable fringe patterns. The magnets 9 may also cause the individual forms to attract and repel each other.

The magnets 9 vary in placement, number of magnets 9 per object 11, size, magnetic strength, shape and chemical makeup. The magnetic poles of the magnets 9 can be arranged to create different optical effects.

The plastic shapes 11 and embedded magnets 9 can be formed to exploit other possible optical effects. For example, prism shapes, lens shapes, wedge effects from the interface between the magnet surface 9 and the material 11 presents an additional optical effect to entertain the user.

Figure 6 shows a polarizing film 13 covering a molded photoelastic plastic object 15. One

or more polarizing films 13 are attached to one or more sides of a molded photoelastic object 15. The polarizing film 13 allows the user to view the fringe effects.

Figure 7 shows a molded photoelastic object 17 with a polarizing film 19 embedded within the object 17. The object 17 is transparent. The film 19 and the object 17 may have any shape or configuration. Varying the shapes creates different visual effects.

Figure 8 shows a photoelastic object 21 between two sheets 23, 25 of polarizing film. If the shapes 21 do not have a polarizing film attached, the plastic shapes 21 can be manipulated between two films 23, 25 to show fringe effects. The films 23, 25 are separated and supported by four posts 27 disposed between the films 23, 25. The posts 27 are located at the corners of the roughly rectangular sheets 23, 25. The sheets 23, 25 are spaced to allow a user to manually manipulate the object 21 while it is held between the sheets 23, 25. The observer 29 views the object 21 through the first polarizing film 23. Light reaches the viewer 29 through one film 25, through the object 21, and then through the other film 23.

Figure 9 shows a photoelastic object 31 between two separate sheets 33, 35 of polarizing film. If the shapes 31 do not have a polarizing film attached, the plastic shapes 31 are manipulated between two films 33, 35 to show fringe effects. A viewer 37 observes light 39 from a light source 41 that passes through a first polarizing film 33, the object 31 and a second polarizing film 35. Each polarizing film 33, 35 may have a stand 43 for placing the films 33, 35 in various positions. This frees up the user's hands to manipulate the object 31. The films 33, 35 are placed in different relative positions to create different visual effects.

Figure 10 shows polarized light 45 from a polarized light source 47 passing through a photoelastic object 49. The polarized light 45 then passes through a pair of polarized glasses 51 worn by a user. In this embodiment, the photoelastic object 49 does not have any attached

polarizing films. The polarized light source 47 and polarized glasses 51 provide the means to view the resulting fringe patterns. A polarized film may be attached directly to the light source 47.

Figure 11 shows another embodiment of the present invention. In this embodiment, light 53 from the sun or another unpolarized light source 55 passes through a first light polarizing film 59. The light 53 then passes through a photoelastic object 57 and then through a second polarizing film 59. Polarizing films are applied directly to the photoelastic object 57. A screen 60 may be mounted on a stand 63 to free the hands of the user to manipulate the photoelastic object 57. Placing stresses on the object in various configurations changes the fringes shown on the screen.

Figure 12 shows the use of polaroids 65, 67 with a photoelastic object 69. Light 71 travels from a light source 73 through a first polaroid 65. The first polaroid 65 is rotated in relation to the light source 73. The light 71 then passes through the photoelastic object 69 and onto the second polaroid 67. This polaroid 67 is also rotated in relation to the first polaroid 65, reducing light transmission. The remaining light 71 then passes through the second polaroid 67 and into the eye 75 of the viewer. The polaroids 65, 67 may be placed on the surface of the photoelastic object 69. The placement of the polaroids 65, 67 on the surface of the photoelastic material 69 or on separate mounts may be varied in order to vary the amount of light 71 transmitted.

Other optical effects may be incorporated into the present invention to enhance the viewing experience of the user. Figure 13 shows a photoelastic object 77 with bubbles or colloidal particles 79 dispersed within the molded object 77. These particles 79 affect the fringe patterns. Figure 14 shows magnets 81 or other objects embedded within a molded photoelastic

object 83. A thin air interface 84 between the embedded objects 81 and the photoelastic material 83 produces interference patterns of light. The surface of the embedded objects 81 may be shiny or opaque. This in turn causes visual effects due to reflection or refraction or light.

Other optical effects may be employed in any embodiment of the present invention. This includes porosity of the photoelastic material, colloidal effects and other optical effects including magnification, reflection, diffraction, and interference patterns of light. Additionally, the shape of the photoelastic object may be formed to have the effect of a prism.

Manipulation of stress levels affects stress patterns. External forces, such as manual manipulation, springs, strings, elastic bands, clamps, embedded and/or externally placed magnets and other devices may also be used to create interesting optical effects.

Figure 15 shows an elongated photoelastic object 85 with a spring 87 connected between opposite ends 89, 91 of the object 85. The spring 87 may have different tensions and different tensions may be combined with objects 85 of varying modulus of elasticity. Each change creates a new and unique fringe pattern in the photoelastic object 85.

Figure 16 shows an elongated photoelastic object 93 with a string or elastic band 95 between opposite ends 97, 99 of the object 93. The string or elastic band 95 creates stress within the photoelectric object 93. The stress then creates fringe patterns that are viewable to the user.

Figure 17 shows a photoelastic object 101 being deformed by external stress 103. External stresses can be applied in a variety of positions and combinations to create different patterns.

Another method of inducing stress, shown in Figure 18, is to create a molded photoelastic object 105 with an interior cavity 107. Another object 109, which may or may not be photoelastic, is inserted into the cavity 107. The second object 109 is larger in dimension than the

interior cavity 107. The stretching of the larger photoelastic object 105 creates stresses that are seen in fringe patterns.

Figure 19 shows one or more magnets 111 embedded within a photoelastic object 113 creating stresses. The magnets 111 within the same object attract or repel each other with force 115, deforming the photoelastic object 113. Additionally, more than one photoelastic objects 113 with embedded magnets 111 may be brought near each other. The force 117 between the magnets 111, in different objects 113, creates stresses in both photoelastic objects 113. The force 117 may cause the objects 113 to attract and stick together, causing more fringe patterns in each, or the force 117 may cause the objects 113 to repel each other.

Figure 20 shows a photoelastic material 119 being deformed by a clamp 121. The photoelastic object 119 is placed between the ends 123, 125 of the clamp 121 and the clamp is tightened by a tightening mechanism 127. As the clamp 121 is tightened, the fringe patterns change as a result of changing stress levels.

Figure 21 shows that lenses 129 may be separately provided to magnify the optical effects of the present invention. A viewer 131 views a photoelastic object 133 through the lens 129. A sharp object 135 may be used to create fringe patterns 137. One or more sharp objects 135 may be used to create various optical effects.

A photoelastic coating is applied to objects as a liquid to be painted or as a flexible sheet. Fringes may be observed as unpolarized light reflects off a surface of an opaque, coated object or off a mirrored surface beneath a transparent or translucent coated object through a polarizing film or films. The polarizing film or films may be applied on the surface of the coating on the object or mounted separate from the object. The mirrored surface may be separate from the object, embedded in the object, or a characteristic of the object itself. An example of a coated object is a

magnet with a glossy finish. Other examples are possible. More than one such object would be able to attract and/or repel other objects. If more than one polarizing film is used, these can be rotated with respect to one another to control the transmission of light.

Figure 22 shows the use of reflection with photoelastic objects. A photoelastic object 139 is composed of multiple layers. The base layer 141 is a reflective surface, coating or sheet. The next layer 143 is a photoelastic sheet or coating. The next layer 145 is a polarizing film. The final layer 147 in Figure 22 is a protective transparent coating or sheet. The photoelastic object 139 may be a flexible sheet, such as a tablecloth, clothing, trampoline parts, boxing glove or punching bag coverings, hand bags or other bags, luggage, shoes, wallets, buttons, jewelry, decorations, frames and many other materials. Layering with reflective materials may also be applied to more rigid applications on items such as chairs, tables, bar stands, bottles, paper weights, pens, pencils, letter openers, boxes, business cards, greeting cards, pet items, decorative features on cars, bicycles, skates, tools, and many other uses.

Applied force 149 causes the deformation of the object 139. Examples of applied force 149 include folding, gravity, placement of dishes on a photoelastic tablecloth, persons sitting on photoelastic chairs, punching a photoelastic punching bag or grasping a pen. Unpolarized light 151 can be from a lamp, candle, the sun or even ambient light. The light 151 passes through layers 143, 145, 147 and is reflected off layer 141. Reflected light 151 then passes back through layers 143, 145, 147 and onto the observer 153.

Photoelastic effects can be used to create fixed, permanent fringes within photoelastic objects through curing techniques and permanent deformation strategies. Permanent deformation strategies create fixed stress patterns in photoelastic plastics. Deformation may be permanently fixed into the photoelastic sheet or coating, creating permanently fixed fringes by unequal cooling

or applied forces during the formative stages of photoelastic material.

Figures 23 and 24 show three-dimensional formulations using reflection. The center 155 of a photoelastic object 157 is made of a reflective surface. A photoelastic layer 159 surrounds the central layer 155. A polarizing film 161 surrounds the photoelastic layer 159, and a protective transparent or translucent layer 163 surrounds the polarizing film 161. Unpolarized light 165 passes through layers 159, 161, 163 and is reflected off layer 155. Reflected light 167 then passes back through layers 159, 161, 163 and onto the observer 169. A force 171 from stretching creates fringe patterns 173.

Photoelastic materials, such as in Figures 23 and 24, may be used for ropes. A rope 157 is designed with photoelastic effects such that the number or fringes 173 in a stretched state corresponds to the amount of force applied. This is both a practical and entertaining use of fringe materials. Force measurements are made with the rope 157. Alternatively, the rope 157 may be used for tug-of-war contests or to encourage physical exercise in children and adults.

Additionally, transparent or translucent molded photoelastic objects can be manipulated between a mirror and a polarizing film or films.

Figure 25 shows a basic general description of formulations using reflection. One or more polarizing films 175 are used. If more than one film 175 is used, the films 175 can rotate with respect to one another to control the transmission of light 177. The films 175 may be mounted separately, directly bonded to the surface of a photoelastic object 179, or embedded within the photoelastic object 179. The photoelastic object 179 is translucent or transparent and varies in size, shape, chemical makeup, modulus of elasticity, color, degree of transparency within one object or from object to object. The photoelastic object 179 is placed over a mirrored surface 181. Force 183 is applied to the photoelastic object 179 by magnets, strings, clamps, springs,

manual manipulation or other devices. The light 177 passes through the one or more films 175, through the photoelastic object 179, and onto the mirrored surface 181. Reflected light 185 then travels back through the photoelastic object 179, the one or more films 175 and onto the observer 187. Additionally, fringe patterns may be projected onto a screen 189 and viewed by an observer behind the screen 191 or in front of the screen 193.

Figures 26 and 27 show formulations using reflections and magnets. The centers 195 of photoelastic objects 197 are magnets made with reflective surfaces. Photoelastic layers 199 surround the central layers 195. Polarizing films 201 surround the photoelastic layers 199, and protective transparent or translucent layers may surround the polarizing films 201. Unpolarized light 205 passes through layers 199, 201 and is reflected off layers 195. Reflected light 207 then passes back through layers 199, 201 and onto the observer 209. Magnetic forces 211 either attract or repel and create fringe patterns.

Figure 27 shows the embedded magnet embodiment of Figure 26 with the polarizing film 201 not attached to the photoelastic object 197. The polarizing film 201 may be mounted to free the hands of the observer 209. A pair of films 201 may be used to control the transmission of light 205.

Figure 28 shows a reflective coating application accessible in three dimensions. A central reflective surface 213 is shaped as a square or rectangle. Photoelastic material 215 covers each side of the reflective surfaces 213. Polarizing films 217 are attached to or embedded within the photoelastic material 215 on all sides. A transparent or translucent protective coating 219 is then applied to all sides of the object 221. Unpolarized light 223 passes through layers 219, 217, 215 and onto the reflective surface 213. Reflected light 225 then travels back through layers 215, 217, 219 and onto the observer 227. Magnets, strings, clamps, springs, manual manipulation, or

other devices to create fringe patterns apply force 229. The observer 227 can observe fringes on one or more sides of the object 221.

Figure 29 is an embodiment of a candleholder or light fixture. A light source 231 is placed in the center of the photoelastic object 233. A light bulb may be a polarized or unpolarized light source 231. Other light sources 231 may include a candle, the sun or ambient light in related applications. Light 235 is emitted from the light source 231 and passes through the object 233 and onto the observer 237. The photoelastic object 233 is composed of a central photoelastic layer 239 covered by a polarizing film 241 on all sides. The inner layer of polarizing film 241 may be excluded if the light source 231 is polarized. The photoelastic material 239 may be of any thickness, including a painted coating. The photoelastic material 239 may be of any color, chemical composition, modulus of elasticity, or degree of transparency. Deformation may be permanently fixed into the photoelastic sheet or coating, creating permanently fixed fringes by unequal cooling or applied forces during the formative stages of photoelastic material.

The purpose of the present invention is to amuse as well as to stimulate an interest in science and engineering in children and adults.

Photoelasticity can be applied to art, artifacts and toys. Examples of uses of photoelastic materials include, but are not limited to: paper weights, trophies, office and household decorations, wall fixtures, embellishment designs on clocks and telephones, designs of candle holders or light fixtures, office supplies including business cards, pens and pencils, holiday decorations, ornaments, bottles for various purposes, containers, storage devices, boxes, furniture, cloths, greeting cards, jewelry, features for decorative windows, placemats, calendars, cups, saucers, plates, utensils, letter openers, CD, DVD, video and record covers or containers, covers generally, knobs, handles, balls, discs, boomerangs, hoops, tubes, hoses, display mounts,

kites, flying toys or artifacts, musical toys or artifacts, dart games, musical instruments, exercise or sports related devices, costumes, masks, swords, jump ropes, bouncing objects, balloons, other inflatable objects, switches, bats, rackets, paddles, hooks, targets, walking canes, sticks, frames for glasses, pictures or photos, umbrellas, wheels, wrapping paper and material, ribbons, bows, ties, artificial flowers and plants, vases, posters, plaques, awards, certificates, signs, book covers, pillows gardening supplies, tools, plastic coverings for electronics, i.e. laptops, mp3 players, video game consoles, toothbrushes, and computer games.

While the invention has been described with reference to specific embodiments, modifications and variations of the invention may be constructed without departing from the scope of the invention.